Remote sensing images and interpretation for "Reverse Difference" phenomenon of the marine sediments At the CaMau tongue (extreme South Vietnam - Mekong Basin)

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Abstract: This paper is concerned with "reverse difference" of marine sediments at the Camau tongue in the extreme south of Vietnam. We demonstrate the importance of remote sensing in geomorphology and marine geological application, using only visual evaluation and some data-processing techniques. In this paper, about 10,000 km^2 of the territorial water in the extreme south of Vietnam is being studied. We show that form and behavior of Mekong and its branch can be determined by visually interpreting remote sensing images and using ERDAS IMAGE 8.5 software. Besides, the "reverse difference" phenomenon is explained by flows of Mekong river and its branches.
Key words: reverse difference, flow, Camau tongue.

1. Introduction

During the interval 1950 to present, the CaMau tongue has gained continuously on the sea about 50-70m per year with extremely fine marine sediments. The < 0.01mm granularity makes up more than 70%. Moreover, there is scarce property in those very fine sediments such as "reverse difference" (?).

Usually, the grain-size of the marine deposits shows a downward tendency from coastline to open sea in the differential process. But, the differential phenomenon contrarily happened at CaMau tongue in Vietnam. The grain-sizes of sediment near the shoreline are finer than the grain-size in the open sea. Clearly, these sediments were deposited in the marine environment at the Camau tongue. However, the original granularity norms of the sediments have proved these depositions to be alluvial sediment.

Thus, this phenomenon is related to the resource and transport environment of material. In this case, it is the Mekong river. In this paper, we used the remote sensing images to determine the direction of Mekong's flow in the shallow sea, and to judge the "reverse difference" phenomenon from the directions of these flows.

a. The studied area

The studied area lies in the sea of Camau small peninsula that about 10,000 km^2 of territorial water in the extreme south of Vietnam. The studied area encloses the whole Camau tongue. The area is part of Thailand's gulf at the west, and it borders to the East Sea at the east. The material of the Camau tongue was primarily created by fluvial sediment of the Mekong river. The average discharge of the Mekong river is 15,000m^3/s, the maximum discharge can reach over 57,000m^3/s in the flood period while during the dry season it is about 2,000m^3/s. Mekong River is the 8th largest river in the world for mean discharge and average suspended sediment load respectively (Meade, 1996).

Every year, the Mekong river discharges itself into the sea with an enormous amount of alluvium, and the most of them are concentrated and deposited at the Camau tongue by interaction between marine and flow of river. Sine 1950, the CaMau tongue gains continuously on the sea about 50-70m per year

Pic 01: Study area on the Vietnamese map

Pic 02: Study area on the Camau

b. Mekong river circumstances

Derived from Tibetan Plateau at an elevation of 5,000m, the Mekong basin stretches across six countries: China, Myanmar, Laos, Thailand, Cambodia and Vietnam. The Mekong river reaches the border between Vietnam – Cambodia at its lower part. In the Vietnamese

territory, the Mekong is long about 250km and it pass to the end at the Eastern Sea with the many branches. There are the 9 branches in the east shoreline of Camau peninsula that are SoiRap, HamLuong, CungHau, Tieu, Dai, Dinh An, Co Chien …Both of them, Tien and Hau river, are primarily branches. And some small branches flow to the Thailand gulf as a Song Doc …Mekong river keeps a significant role in this area on domestic water supply, transportation, irrigation, drainage, aquatic resources and more. Many villages and towns are located along the streams and totally 50% of the Mekong delta population lives on the Mekong River.

Geologically, Mekong delta is of a typical formation of Quaternary and recent sediment, especially there was a hidden fault at Mekong river sank under the delta from TonleSap big lake (in Cambodia) to the river mouth area. This fault also is a border area between the ancient orogenenic stages (of tectonic phases). These conditions make the river flow in a northwest – southeast direction from the mainland to the sea, and the soil texture of the riverbank is unstable.

2. Method

a. Data used

In this paper, we use 14 digital images captured by a MODIS sensor of two satellites, Aqua and Terra, during 3 years period (2001-2003).

The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm. Two bands are recorded at a nominal resolution of 250 m at nadir, with five bands at 500 m and the remaining 29 bands at 1,000 m. A ±55-degree scanning pattern at the EOS orbit of 705 km achieves a 2,330-km swath and provides global coverage every one to two days.

In this image collection, 9 of the images were taken from TERRA satellite. "Terra," Latin for land, is the name of the Earth Observing System (EOS) flagship satellite, launched on December 18, 1999. Terra is a vital part of NASA's "Earth Science Enterprise".

The remaining images were taken by the AQUA satellite. "Aqua", Latin for water, is a NASA Earth Science satellite mission named for the large amount of information that the mission will be collecting about the Earth's water cycle. The Aqua mission is part of the NASA-centered international Earth Observing System (EOS).

There are two seasons in the Camau tongue and South Vietnam. The climate of the Camau and South Vietnam has two very different seasons. This difference influenced so much on the flows of Mekong. In this paper, we considered the remote sensing images that was captured in both of seasons at the Camau tongue.

List of images used

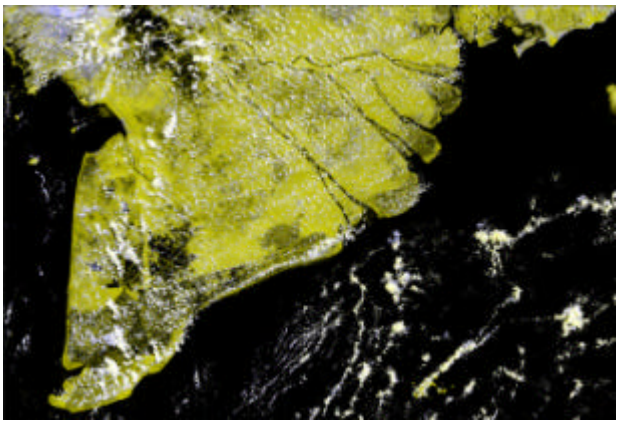
Numb	Date	Sensor	Satellite	Image	Color
1	01/07 2003	MODIS	AQUA	Digital	True
2	01/29 2003	MODIS	TERRA	Digital	True
3	01/29 2003	MODIS	TERRA	Digital	True
4	01/20 2003	MODIS	TERRA	Digital	True
5	01/13 2003	MODIS	AQUA	Digital	True
6	01/13 2003	MODIS	AQUA	Digital	True
7	01/13 2003	MODIS	AQUA	Digital	True
8	11/28 2002	MODIS	TERRA	Digital	True
9	10/20 2002	MODIS	AQUA	Digital	True
10	08/29 2002	MODIS	TERRA	Digital	True
11	08/29 2002	MODIS	TERRA	Digital	True
12	08/01 2002	MODIS	TERRA	Digital	True
13	08/01 2002	MODIS	TERRA	Digital	True
14	09/25 2001	MODIS	TERRA	Digital	False

In this paper, topographic maps are used, too. These topographic maps were constructed during the period 1998-2000 from geometric measurements in scale 1: 50,000 and UTM projections with zone 48. The topographic maps have been corrected and edited by the aerial images, the last update was 2001.

b. Flows of Mekong's river and reverse difference phenomenon

All images were geo-rectified to topographic maps of UTM in preprocessing before interpreting and analyzing. In order to extract shorelines and flows from images, each type of images was processed with a different method based on the level of distinction between water – land and soil – vegetation that the image can reveal.

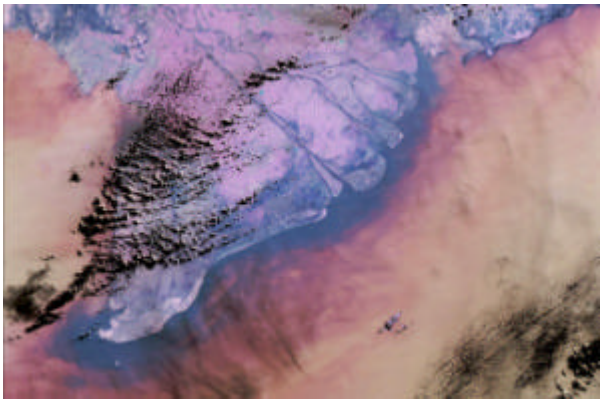
Pic 03: The remote sensing image captured on 01/17 2003 with true color.



Pic 04: Determining the topological coastline of Camau small peninsula based on the RS image captured on 08/01 2002 with ERDAS IMAGE 8.5 software.

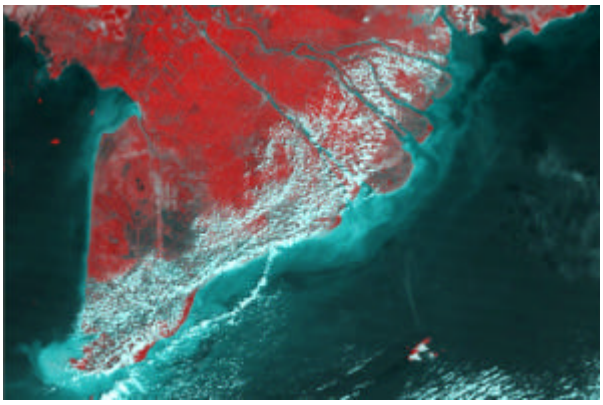
There are two seasons in the Camau tongue and South Vietnam. That it's why the flow direction of Mekong was determined by the interpretation of remote sensing images that was captured during the same season. In the next processing process, the matching algorithm was

used to gather the flow directions that were found by the different remote sensing images. Finally, the general flow of the each season is presented on the topological map in scale 1: 50,000. Thus, the general flow's direction of Mekong on the each season is determinable.



Pic 05: The image shows the east part of general flow of the Mekong river. These remote sensing image were captured on 01/07 2003. On the image, the blue-violet color indicates the east flow of Mekong. The bluish is an indication of wetland. As you can see, the primary direction of the flow of Mekong is east south and the Mekong usually flows along the coastline of Camau small peninsula.

The east flow of Mekong contain the most of deposition that supplies for sedimentary process in the Camau tongue. This is primarily material resource for constructing Camau tongue. Otherwise, the Camau tongue was shaped essentially by the silt soils of east flow of Mekong.



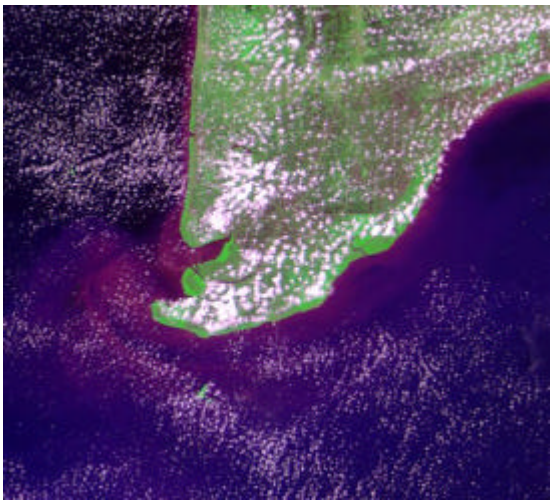
Pic 06. The image shows the west flow of Mekong river. This remote sensing image was captured on 01/13 2003. On the image, the cyan color indicates flows of Mekong. The dark green regions show the wetlands. The red big regions show the forests and the inundated forests are indicated by the dark red regions on the RS image. The white and whitish regions are clouds.

As you can see on the RS image after processing, the general direction of the west flow of Mekong is north – south or semi-meridian. Like the east flow, the general tendency of the west flow is also to flow along the west coastline of the Camau tongue.

The contribution of the west flow is not much in the material transportation process and material resource. Nevertheless, the role of the west flow is ver Otherwise y important in the deposition process of the sediments in the Camau tongue. Otherwise, the west flow of Mekong is vital factor to shape the Camau tongue and occur the "reserve difference" phenomenon.

The east and west flow of the Mekong meet each other in the offshore Camau tongue at a near-shore shallow-sea place. The interaction between two those flows makes a strong eddy at the Camau tongue. Simultaneously, the material sediments of the Mekong are also churned by the influences of these eddies and waves.

Pic 07: The whirl of the seawater in the offshore of Camau tongue at 01/13 2003



Pic 08: The whirl of the seawater in the offshore of Camau tongue at 09/15 2001

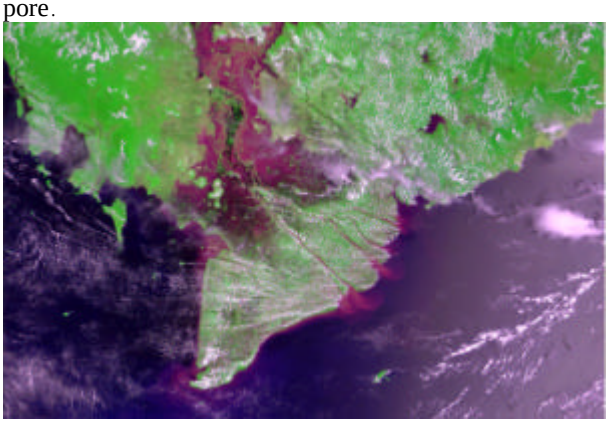
The west flow of Mekong and the waves not only churned the material depositions of the Mekong and the seabed but also transported those materials following the coastline with west-south direction. The material sediments are gradually pushed into the offshore by the waves and the tides. This is the main stage for the occurrence the reverse differential phenomenon.

The reverse difference process occurs strongly with supports of the topology of seabed. The sunken side-wall of the shoreline in the studies area is gentle slope (slopingly) and shallow. The geochemical environment norms of the sediments have proved these depositions to be marine sediment. But the original material resource that derived from Mekong in a lot variant stages.

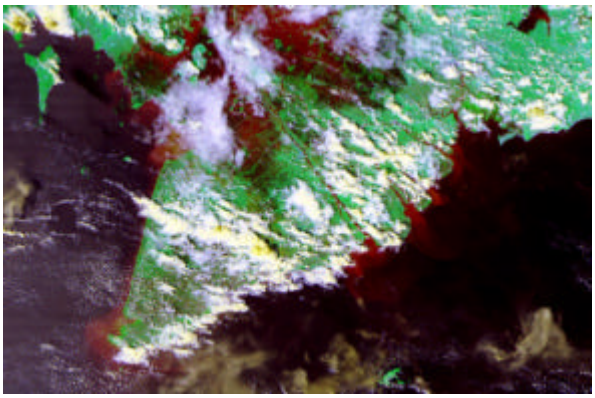
In the rain (or flood) season, the Mekong's flow increases considerably in the intensity, especially at the Mekong river-crab. Nevertheless, the general direction of the Mekong's flow is not change as much as the flow in the dry season. And the reverse differential process continuously occurs even in the flooded season.

The two remote sensing images below show flooded season of Mekong at the 2001 and 2002. In the flood season, the Mekong's flows are very strong and the

flood-plane spreads very large. Especially in 2000, severe floods have affected many places in early August. This flood has been reported to be the most severe in 40 years. The flood area is estimated to affect over 30,000 square kilometers, more than 50 times the size of Singapore.



Pic 9: The flood area at Mekong basin. The remote sensing image captures at 09/15 20001



Pic 10: The flood area at Mekong basin. The RS image captures at 10/20 20002

3. Conclusion

This is an exercise in optimizing information retrieval from satellite images using only visual interpretation and simple computer-based analysis. We try to build a close relationship between geomorphologists, environmental managers, marine geologists and remote sensing image users. In this paper, the reverse difference phenomenon is explained by remote sensing images and simple computer-based analysis. That is the result of the conflict between the east and west flow of Mekong river with the active collaboration of waves and tides. The deposited material with alluvial origin of the Mekong creates those sediments in the marine environment at the Camau tongue. This is the scare physiognomy of marine sediment as a present marshy-clay offshore

We may reach the following conclusions from this study on the lower section of the Mekong basin.

- A very large area can be quickly mapped for flow characteristics, changes of the shorelines and flow analysis by using remote sensing images.
- Effective scope of the river to the sea is easily determined by using simple tools of remote sensing processing software. We are even be distinguish between the main flow (content the alluvia) and the ephemeral flow of the Mekong on the sea.
- Such mapping indicates areas that are shapeable to future development projects and choice of techniques for management of wetland, inundated forest flows and seaboard.
- Even visual interpretation provides a reasonably accurate picture of landforms and ongoing processes. Visual interpretation therefore can be used at least for a reconnaissance study. This is particularly useful for large areas and difficult terrain.
- An enormous amount of information currently remains stored in the archived images. These can be used for time-based analysis and a conceptual model for seasonal changes.

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